International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 8, Issue 2, Apr 2018, 781-790

MULTI OBJECTIVE OPTIMIZATION FOR DRILLING PROCESS STRESSES IN SS317 MATERIAL

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ABSTRACT

Machining of SS317 alloy material is very difficult, because of lower elasticity, a High range of formability and the inclination of breakages. The drilling of AISI SS317 alloy material and High -Speed steel (HSS) are performed to make a drilling in the different hole, it creates poor surface roughness and failure of tool angle. In this study, to optimize the machining in multi- objective performance characteristics in the drilling of SS317 material using Taguchi ANOVA techniques, to optimize better surface finishing and tool wear. Drilling techniques are designed by response surface methodology (RSM) with suitable speed, feed rate, and selected tools helix angles. A multiple response optimization techniques were performed to minimizing the surface roughness, toll flank wear which is used in optimum cutting parameters of modern manufacturing in the drilling process.

KEYWORDS: Stainless Steel, HSS Tool, Helix Angle, Surface Roughness & Multiple Response Optimizations

Received: Feb 20, 2018**; Accepted:** Mar 04, 2018**; Published:** Mar 14, 2018**; Paper Id.:** IJMPERDAPR201889

Original Article

INTRODUCTION

Stainless steel (SS317) alloy material having very good mechanical properties like higher hardness, high corrosion resistance, high strength, and stiffness. The SS317 material commonly used for various functional applications in aerospace industries, Bioengineering equipment, material cutter, and various defence applications. It classifies joining material structures of drilling process is necessary, but it causes damages in a drill hole, drill tool, delimitation laminar crack. N this case have to be performed in carbon fiber reinforced plastic material used in multiple performance characterizations in various experimental work [1]. Some of the metal matrix composite materials having a high strength and stiffness, but other phases of atomic structures in aluminum metal matrix composite got damaged because of irrelevant input properties applied in multiresponse values surappa M. K and Gopalakrishnan et al [2,3]. Lin et al has identified material damage and better surface roughness in carbon fiber composite material series the effect of various cutting parameters used in response surface methodology (RSM) [4]. The silicon grade aluminum composite materials having various applications which are used in aerospace, pistoncylinder links, brake drums, but the effect of addition graphite material and cutting tool introduced in wear, this process has been functioning in multiregression equations [5,6]. Rawat et al [7] have investigated the delamination, Surface roughness, Thermal damage of carbon fiber composite materials used in machinability maps, finally results have been performed in tool wear and material roughness to change in various input parameters of thrust force and cutting force. Shyha at al [8] was presented an L_{12} Taguchi optimization technique ANOVA effect of carbon fiber reinforced plastic laminate (CFRP) identified in drill tool life and hole quality of composite materials. In the drilling of composite materials maximum identified in good quality of surface and increased in material removal rate, Input parameters are identified and drilling problem has reduced was conducting grey functional analysis is used to achieving a good quality of output performance characterization [9-10]. The other

machining process for milling, Turning, [11-12] Welding of a Surface defect to be identified in the multi objective for fuzzy grey relational analysis optimization is involved. Ankita et al [13] performed in multiple geometry of fuzzy relation techniques has been implemented the quality of the submerged arc welding in an aluminum composite material. Sivakumar, V et al [14] investigated in Multi -objective optimization in the CNC Milling Process of Aluminium, copper, Zinc alloy matrix composite used in Taguchi ANOVA techniques and grey relational Techniques. Yavuz Kaplan et al [15] was Identified in various drilling parameters used in hard materials in the HSS drilling tool used in a linear regression model measured in surface roughness. It is a significant of cutting speed and feed in a drilling of hard materials. Venugopal et al [16] reported high cutting in the machining of temperature in titanium alloys is generated in rapid tool wear, because of more amount heat produced during the time of metal cutting. Turgay et al [17] stated in optimized drilling parameters in Taguchi optimization techniques in AISI 316 stainless steel on a CNC machine. Here various input parameters are performed and create better surface roughness in higher temperature Machinability for PVD monolayer and multilayer coated HSS drill toll bits. DENG [18-19] performed in poor and incomplete performance output in grey system because of incomplete output performance, but the multiple performance characterization of grey relation analysis has been better performance optimization techniques in alloys and composite materials. Parthipan et al [25] investigated in drill hole surface roughness measurement in SS317 material. In this paper is represented in ANOVA Taguchi and Response surface methodology process optimized for various machining parameters in the drilling of AISI 317 alloy composite material. The performance output characteristics of surface roughness, wear of helix angle are influenced by progression parameters of cutting speed, feed rate and various tool angles. Response Surface Methodology optimization techniques used in significant parameters are identified, the ANOVA Taguchi approach provides in practical resolution measured in better performance parameters of given workpiece and tool with the multiple response characteristics.

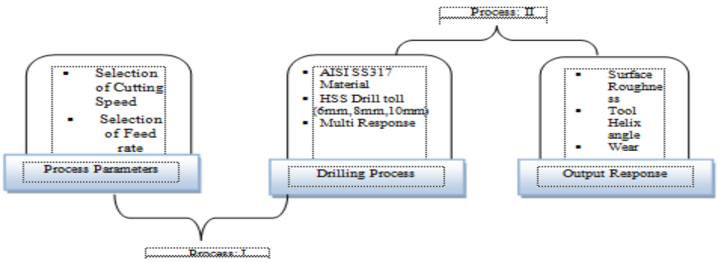

Figure 1: Process Parameters Variables

Machining of SS 317 material having various process parameters above are shown in Figure 1. It is developing in various input and output responses used in multi- regression values. The multi response values Grey Relational values and fuzzy logic in conditional values has major aim to produce better output in a single performance optimization.

CHARACTERISTICS OF MATERIAL

MATERIAL USED

AISI SS 317 grade metal alloy composite material was used in a matrix material, In the present work total dimension of material is 100mm x 100mm x 5mm respectively. In this material higher hardness, stiffness, high corrosion resistance and higher thermal properties the chemical composition as shown in table 1.

Table 1: Chemical Composition of SS 317 Material

Element of Composition	Cr	Ni	Mo	Mn	Si	P	C	S	Fe
Percentage %	19	13	3.50	2	1	0.045	0.080	0.030	61

DRILL TOOL USED

The selection, drilling tool was used in high -speed steel (HSS) drill bit in various size 8.5mm, 9.5mm, 10.5mm respectively. In this tool commercially available and each can machining of required size. The point angle of 1180 degree and Helix angle is 250 - 300. The drilling was conducted based on a thickness of workpiece.

EXPERIMENTAL DESIGN

The drilling experiment was carried out in Response surface methodology on SS 317 with highspeed steel (HSS) drill bits in various diameters. The RSM experimental study is to minimize and selected for responsible input parameters or factors. The Process of input parameters is given below in Table 2.

Table 2: Drilling Process Input Parameters

Factors	Unit	Level - I	Level – II	Level – III
Spindle speed (SS)	RPM	500	800	1000
Feed Rate (FR)	mm/min	10	12	14
Helix Angle (HA)	Degrees	25^o	30^o	-

The drilling experimental work has been conducted in a radial drilling machine, the capacity is 4000rpm and 2.5kW power. The surface roughness was measured in Mitutoyo subtonic tester SI 20P. and also delamination factor was measured in profile projector on micro V30 in top metrology pvt ltd. In a maximum magnification is 1000X in a contour illumination.

WORK PIECE PROCESS

Figure 2(a): Workpiece for Completed Process

Figure 2 (b): HSS Drill Tool

Figure 2(c): Tool Wear

In order to identify the selected optimum cutting parameters in the drilling of SS317 material, which was totally eighteen experimental design and experiments was conducted with 10mm diameter of drill tool. The drill HSS drill tool was used as shown in figures 2(b)

In order to this work given concentrated for helix angle, spindle speed, a feed rate of process parameters with two levels of helix angle and three levels of feed rate three levels spindle speed have to be measured and conducted drilling process parameters shown in figure 2(a).

RESULT AND DISCUSSIONS

ANALYSIS OF VARIANCE (ANOVA) FOR SURFACE ROUGHNESS

The surface roughness every experiment was measured with the Talysurf Measurement instruments. The output of experimental results is given below the table 3. In this experiment mainly focusing on the roughness of the hole in each experimental output was measured in mean surface roughness shown in given table.3

Table 3: Design of Experimental Results of Surface Roughness (Ra)

	Input Parameters (DOE)						
Sl. No	**Helix Angle (HA)**	**Feed Rate (FR)**	**Spindle Speed (SS)**	**Ra1**	**Ra2**	**Ra3**	**Mean Value (Ra)**
1	25	10	500	2.26	2.66	2.81	2.577
2	25	10	800	2.21	2.63	3.33	2.723
3	25	10	1000	2.2	2.72	3.13	2.683
4	25	12	500	2.3	2.68	3.48	2.82
5	25	12	800	2.58	2.83	3.17	2.86
6	25	12	1000	2.17	2.28	3.1	2.517
7	25	14	500	2.14	2.91	3.19	2.747
8	25	14	800	2.17	2.3	3.05	2.507
9	25	14	1000	2.61	2.77	2.97	2.783
10	30	10	500	2.18	2.37	2.68	2.41
11	30	10	800	2.18	2.39	2.79	2.453
12	30	10	1000	2.47	2.67	2.87	2.67
13	30	12	500	2.16	2.43	2.83	2.473
14	30	12	800	2.51	2.67	2.93	2.703
15	30	12	1000	3.71	3.92	4.33	3.987
16	30	14	500	2.71	2.71	2.91	2.777
17	30	14	800	3.77	3.96	4.22	3.983
18	30	14	1000	2.98	4.13	4.27	3.793

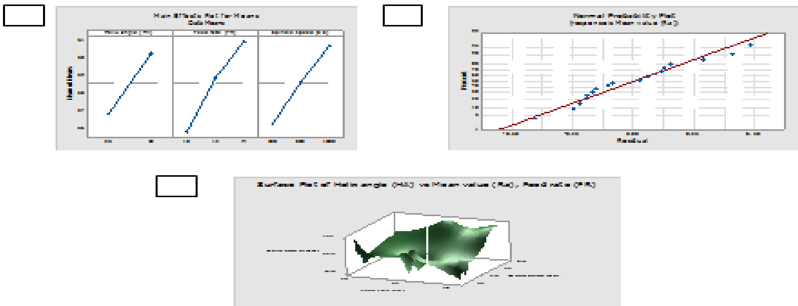

Figure 3A): ANOVA Design Curve B): Normal Probability Residual Stress of Surface Roughness, C): Effect of Feed Rate, and Helix Angle of Surface Roughness in Mean Plot.

Figure 3(a) and (b) is a normal probability plot of residual surface roughness that indicates various behaviors of residual values. More than 95% of experimental design data of residual values are measured. Figure 3 (c) is a surface roughness 3Dimentional view based upon the spindle speed and conflux of the helix angle on the surface roughness. At high spindle speed and maximum helix angle of a drill, in higher frictional stresses have been found to develop the rapid tool wear by the diffusion.

The model terms which are having in p-value is less than in 0.05 are to be considered as significant, where the p-value is 0.0038,0.0197,0.0125 are respectively. All the different three parameters are to be found in significant on the

surface roughness. The R2 and adjusted R2 value are to 0.8826 and 0.8640 respectively. Because of the high spindle speed and feed rates, the deformation of resistance and thermal softening in SS317 are more than more energy is required for plastic deformation of the metal.

Table 4: ANOVA for Surface Roughness

Sources	Sum of Sqa	Df	Mean Sq	F Value	P Value
Model	3.24	6	0.54	6.61	0.0038
A-H A	0.61	1	0.61	7.44	0.0197
B-F R	0-77	1	0.73	8.93	0.0125
C-SS	0-58	1	0.58	7.06	0.0224
AB	0.63	1	0.62	7.65	0..0186
AC	0.61	1	0.61	7.46	0.0197
BC	0.088	1	0.088	1.08	0.3223
Residual	0.90	11	0.082		
Cor Total	**4.13**	**17**			
Std. Dev = 0.29		R^2 = 0.8826		Press = 2.68	
Mean = 3.03	Adj R^2 = 0.8641			Adeq Preci = 10.33	
C. C in Per % = 9.43	Pred R^2 = 0.8523				

ANALYSIS OF VARIANCE FOR DRILL TOOL FLANK WEAR

After the drilling hole was completed to measure the flank wear of machine vision system. There are totally four holes were developed on the workpiece in each experiment. Totally flank wear for eighteen experiments was conducted and measured in table 5. In mean average value of flank wear to be identified in a given parameter.

Table 5: Design of Experiment of Drill Flank Wear

Sl. No	Helix Angle (HA)	Feed Rate (FR)	Spindle Speed (SS)	Flank Wear 1	Flank Wear 2	Flank Wear 3	Mean Value Flank Wear (VB)
1	25	10	500	0.1367	0.1305	0.1718	0.146
2	25	10	800	0.1855	0.1364	0.1756	0.166
3	25	10	1000	0.3113	0.1827	0.1718	0.222
4	25	12	500	0.1856	0.1396	0.1766	0.167
5	25	12	800	0.1767	0.1856	0.1768	0.18
6	25	12	1000	0.3113	0.3127	0.1715	0.265
7	25	14	500	0.3113	0.1966	0.1717	0.227
8	25	14	800	0.2114	0.3113	0.1715	0.231
9	25	14	1000	0.3013	0.3067	0.3003	0.303
10	30	10	500	0.2132	0.1856	0.1992	0.199
11	30	10	800	0.1516	0.1568	0.1874	0.165
12	30	10	1000	0.1577	0.1617	0.1853	0.168
13	30	12	500	0.1509	0.1633	0.1897	0.168
14	30	12	800	0.1616	0.1799	0.1806	0.174
15	30	12	1000	0.2113	0.2863	0.2887	0.262
16	30	14	500	0.1668	0.1961	0.1898	0.184
17	30	14	800	0.2126	0.2931	0.2923	0.266
18	30	14	1000	0.1616	0.2866	0.3097	0.253

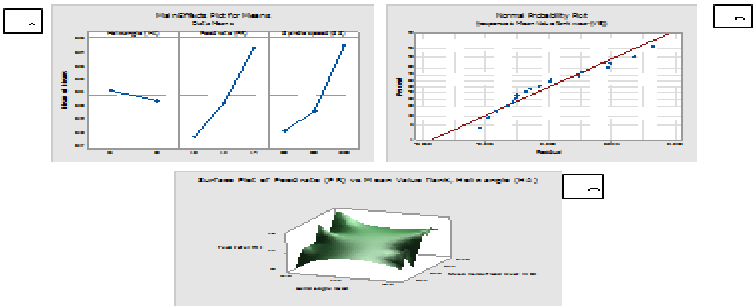

Figure 4 A): ANOVA Design Plot for Flank Wear B): Normal Probabilities of Residual Flank Wear C): Effect of Spindle Speed and Helix Angle in 3D Vision of Flank Wear

Figure 4(a)(b) is a normal probability design plot to reduce the flank wear that indicates the various behaviors of regression residuals. In this flank wear session, the represents at 95% of confidence level of analysis experimental data analysis. It shows that increase the flank wears to given feed rate helix angle and selected drill rotation in spindle speed, Figure (c) represents that 3Dimentional flank wear increases within high spindle speed and helix angle of drill, in frictional stresses have been developed and causes of generations in heat of tool and workpiece cutting area. The heat, which was dissipated to the drill bit to increase the wear of flank by adhesion and diffusion of various cutting mechanisms.

Table 6: ANOVA for Tool Flank Wear

Source	Sum of Squars.	Df	Mean Square	F Value	P-Value Prob>F
Model	0.027	6	4-410E-003	9.96	0.0007
A-H A	6.43E+04	1	6.43E-04	1.45	0.2534
B-F R	0.012	1	0.012	27.68	0.0003
C-S s	0.011	1	0.011	25.62	0.0004
AB	4.17E-04	1	4.17E-04	0.94	0.353
AC	1.24E-03	1	1.24E-03	2.8	0.1224
BC	5.60E-04	1	5.60E-04	1.26	0.285
Residual	4.87E-03	11	4.43E-04		
Cor Total	**0.031**	**17**			
Std. dev = 0.021		R^2 = 0.8985		PRESS = 0.012	
Mean = 0.22		Adj R2=0.8967		Adeq Precision = 12.004	
C. V % = 9.66		Pred R2 = 0.9050			

In above table 6 shows that Analysis of variance at 95% of a confidence level of analysis in experimental data analysis in flank wear of the tool. The ANOVA experimental design of surface roughness was presented in table6 was executed in p-value of 0.0007 that indicates various models significantly. The spindle speed and feed rate having the p-values are 0.0003 and 0.0004 respectively. These represent parameters are to be found in significant mechanism on the flank wear. The R2 value and adjacent values have been found in 0.8985 and 0.8967 respectively. The signal to noise ratio was greater than 12.004. The Low thermal conductivity and stainless steel alloy material result is shown in temperature and pressure in the workpiece and tool wear is increased at high speed and feed rate.

MULTI OPTIMIZATION RESPONSE

In this research study, a multiple response optimization techniques was used to measure in drilling parameters in less surface finish measurement, lowest flank wear. It has overcome in single response optimization in multi optimization response techniques. In this response, the optimization process is calculated in a gradient algorithm between 0 to 1 range. The selected process parameters were carried out to minimization of lowest surface roughness and, and flank wear the mentioned has given figure 5.0

The optimum cutting parameters have been found at26.160 of helix angle, 10.0 mm/min of feed rate and 500rpm of selected spindle speed. A selected values were found in be in 0.997,0.095 and 1.0 for good surface roughness and flank wear. The better values which are close to 1 indicates better accept optimization is executed in Minitab 17 software was used in optimization process parameters.

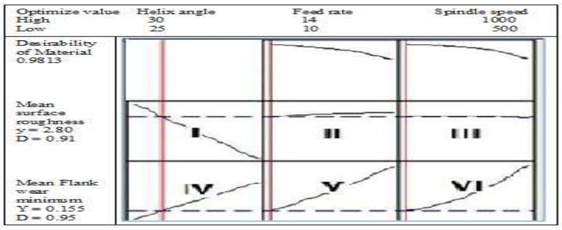

Figure 5: Multi Objective Response Functions for Surface Roughness and Tool Flank Wear

CONCLUSIONS

The experimental work was carried out in a SS317 material to investigate the spindle speed, helix angle and feed rate on surface roughness measurements and flank wear.

The following measurement of a conclusion is suitably formulated.

- In high spindle speeds the helix angle of drill, in higher frictional stress has been developed and that was cause for the generation of heat in the cutting area. The heat was dissipated in given drill bit to increase the flank wear by the adhesion and diffusion of mechanisms.
- The ANOVA confirms that the nominal mathematical models of surface roughness, flank wear well fitted in grammatical input and output parameters.
- Surface roughness increases as well as spindle speed and feed rate also increased, but the cause of an effect in helix angle on the surface roughness found to be less.
- The optimized process parameters were carried out for minimization of surface roughness, flank wear in optimum cutting parameters were found that 26.170 of helix angle, 10.0 mm/min of feed rate and 500 rpm of spindle speed.

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